Bob Zubrin, Mars & Beer
This Week on The Space Show

NASA Funds Radiation Shielding Projects Under SBIR Phase II Program

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by
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The base is first unfolded from a tubular module that can be easily transported by space rocket. An inflatable dome then extends from one end of this cylinder to provide a support

structure for construction. Layers of regolith are then built up over the dome by a robot-operated 3D printer (right) to create a protective shell. (Credit: Foster + Partners)

NASA has selected three projects aimed at providing radiation shielding to astronauts on deep space missions for continued funding under its Small Business Research Innovation (SBIR) Phase II program.

The projects include:

- *Hydrogenous Polymer-Regolith Composites for Radiation-Shielding Materials.* International Scientific Technologies, Inc., Dublin, Va.
- *Multifunctional Structural Composites for Radiation Shielding.* Applied Poleramic, Inc., Benicia, Calif.
- *Multifunctional Polyolefin Matrix Composite Structures.* TDA Research, Inc., Wheat Ridge, Colo.

Descriptions of the projects follow.

International Scientific Technologies, Inc.
Dublin, VA

Proposal Title: Hydrogenous Polymer-Regolith Composites for Radiation-Shielding Materials
Subtopic Title: Radiation Shielding Technologies

Principal Investigator/Project Manager
Eugene C Aquino

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 5

Technical Abstract

NASA has identified a need in Sub-topic H11.01 for advanced radiation-shielding technologies using in situ resources, such as regolith, to protect humans from the hazards of galactic cosmic radiation (GCR) during extra-terrestrial missions. The radiation species of greatest interest are light ions (particularly protons), heavy ions (such as iron-56) and neutrons. International Scientific Technologies, Inc., in conjunction with The College of William and Mary, proposes the use of regolith combined with hydrogenous polymers to develop radiation-shielding structural materials for habitats. The program Technical Objectives include analysis of polymer-regolith specimens to supplement the empirical results of the Phase I program, fabrication of polymer-regolith materials and structures for use as radiation shields, acquisition of families of test data to determine key parameters of polymer-regolith structures for stopping galactic cosmic radiation on the Mars surface, and design of polymer-regolith bricks for habitat construction of the Mars surface. The innovation is the development of polymer-regolith composites and their efficient fabrication for structural radiation-shielding materials to protect humans on deep-space missions. The anticipated result is the creation of composite materials that combines in situ resource utilization (ISRU), i.e. regolith, with a hydrogenous polymeric matrix. Additives, such as boron, could be included to enhance absorption of neutrons generated by interactions of GCR and SPE particles with shielding materials. The proposed composites have multifunctional properties of radiation shielding against galactic cosmic radiation, neutrons and electromagnetic radiation, and structural integrity to permit use in habitats.

Potential NASA Commercial Applications

The proposed multifunctional high-performance polymers will find application in NASA missions in protecting astronauts and sensitive optical, electronic, thermal and acoustic components from space hazards, including radiation, dust and thermal transients, while, at the same time, providing structural

components for habitats. It is expected that these polymer-regolith composite systems will provide a high-performance-to-weight radiation shield that can be used for human habitats.

Potential Non-NASA Commercial Applications

Multifunctional radiation shielding will find application in the commercial sector in reducing collateral damage from heavy charged particles emerging as a therapeutic approach in nuclear medicine. The Departments of Defense and of Homeland Security will find applications that include protection of soldiers, first responders and emergency medical personnel against high energy gamma radiation and neutrons resulting from so-called dirty bombs as well as from hazards brought about through accidental release of radiological materials.

Applied Poleramic, Inc.
Benicia, CA

Proposal Title: Multifunctional Structural Composites for Radiation Shielding
Subtopic Title: Radiation Shielding Technologies

Principal Investigator/Project Manager
Brian S Hayes

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 4
End: 6

Technical Abstract

Radiation shielding materials are necessary for protecting astronaut crews from the hazards of space radiation during future NASA missions. Although polyethylene based materials and composites are attractive for radiation shielding due to high hydrogen content, the poor thermal performance has limited its use as a parasitic, nonstructural material. Further impeding use of this material is its inherent flammability. Accordingly, thermally stable structural materials having low flammability combined with radiation shielding are necessary for the development of next generation aerospace structures and vehicles. It would be further desirable that the non-parasitic material has excellent damage tolerance to mitigate impact events in operation. Applied Poleramic, Inc. proposes to develop a new generation of structural high hydrogen content matrix materials which will be combined with an interlayer modification approach to result in fiber reinforced composite materials having enhanced radiation shielding combined with excellent damage tolerance and improved flammability resistance.

Potential NASA Commercial Applications

Composite materials having enhanced radiation shielding and multifunctional characteristics can provide design advantages for future spacecraft, large space structures, space stations, orbiters, landers, rovers, and habitats. Some vehicles include the Orion Multi-Purpose Crew Vehicle (MPCW) and future Multi-Mission Space Exploration Vehicles (MMSEV). The developed technology may also find use for radiation shielding of cargo transportation vehicles and unmanned space vehicles to protect sensitive electronics and instruments.

Potential Non-NASA Commercial Applications

Commercial applications come from NASA funded crew and cargo space transportation partners including Dragon, SpaceX, Dream Chaser, Sierra Nevada Corporation, Crew Space Transportation-(CST)100, The Boeing Company, Crew Transportation System, Blue Origin, and Cygnus, Orbital Sciences Corporation. Other applications may be found in DOD applications involving high altitude reconnaissance aircraft, satellites, and other aerospace vehicles. Other commercial applications could be found in commercial

satellites and manned and unmanned aircraft to protect sensitive electronic equipment and instruments.

TDA Research, Inc.
Wheat Ridge, CO

Proposal Title: Multifunctional Polyolefin Matrix Composite Structures
Subtopic Title: Radiation Shielding Technologies

Principal Investigator/Project Manager
Dr. Michael D. Diener Ph.D.

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 4
End: 5

Technical Abstract

Polyethylene, and ultrahigh molecular weight polyethylene (UHMWPE) in particular, is an outstanding material for radiation shielding in the sense that its extraordinarily high hydrogen content both minimizes the production of secondary ions during exposure to energetic radiation and captures neutrons. Its low density and high wear resistance also make it attractive for the structures of manned spacecraft and extraterrestrial habitats. However, its use in structures is limited by its flammability and poor mechanical properties under load compared to other structural materials. While carbon fiber/UHMWPE are an obvious solution, to date they have not proved useful because load is not easily transferred to or from UHMWPE, and because its melt state is too viscous to infiltrate fiber preforms. In this Phase II project, TDA will apply its recent advances in composite manufacturing to create a UHMWPE-matrix composite that has good load transfer to a creep-mitigating continuous fiber reinforcement. Such a composite will not only have outstanding radiation shielding properties, but also have sufficient mechanical properties to be useful as a structural material.

Potential NASA Commercial Applications

Multifunctional radiation shielding was identified as the top technical challenge in the Materials, Structures, Mechanical Systems and Manufacturing (MSMM) draft Roadmap (Technical Area 12), and the technology proposed herein offers a solution. The composites proposed herein should be a key components of the structural materials used in extraterrestrial human habits, whether they are in space, on the moon, on Mars, or any other location subject to high energy galactic cosmic rays and/or solar particle events. The lightweight and high strength of the proposed materials will enable their use in efficient structures, providing true multifunctionality from a radiation shield and minimizing the parasitic weight of the shielding.

Potential Non-NASA Commercial Applications

The Cf/UHMWPEm composites should be commercially useful in other wear-resistant structures, including mining equipment and ballistic threat protection. Self-reinforced UHMWPE composites dominate the market for lightweight armor, and the composited proposed herein should provide a complementary but similarly outstanding set of properties for mitigating a broad spectrum of ballistic threats. UHMWPE is widely used in the bed liners of mining equipment, and the composite materials proposed herein should extend the use of UHWMPE into other hard rock handling structures.

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